Incorporating "The Illuminating Engineer."

Light and Lighting

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Standardisation by Consent

AN instructive section of Mr. Percy Good's Presidential Address to the Illuminating Engineering Society, which is summarised on p. 119, and is reproduced in full in the Society's *Transactions* for May, was his account of Standardisation in Illuminating Engineering.

It has become an established practice for problems and processes to be referred to the B.S.I. as soon as they are ripe for standardisation, and Mr. Good presented an impressive list of specifications, already issued or in course of preparation, relating to illuminating engineering. Such specifications ensure good performance but do not act as a deterrent to progress. They can always be revised and amended as soon as time is ripe for a change.

A more difficult and yet vital step is the issue of a "hallmark" or certification mark, a guarantee of quality. This is tied up with the problem how to prevent its misuse. Prosecutions, involving pains and penalties, have been tried in the past, for example, by those early bodies of illuminating engineers, the Guilds of Wax and Tallow Chandlers. They are difficult to apply and afford no real protection.

A modern method, which the B.S.I. has evolved and which is already being operated in 100 different factories, is essentially "Standardisation by Consent." The B.S.I. mark is given only to such concerns as are prepared to control the quality of their own products. Australia and New Zealand have recently accepted the view of the B.S.I. that the only effective control must be exercised at the point of production.

I.E.S. Council's Annual Report

The annual report of the Council of the Illuminating Engineering Society always affords members a good opportunity of taking stock. The salient points revealed in the report for the past session, presented at the annual meeting on May 10, were the great increase in the number of meetings, over fifty, as compared with half a dozen but a few years ago, and the steady growth in membership. The latter is largely associated with the activity of the Local Centres, which, in several instances, have made substantial progress, and are now forming sub-centres in various areas, where additional meetings will in future be held. It is obviously essential that special measures should be taken to keep these various centres in touch with the parent body, and to enable members in the various areas to get to know each other. The plan adopted for the first time this year, of inviting the chairmen of Local Centres to attend the annual dinner in London and to join a conference on problems of common interest held on the following day, is an excellent one. The arrangement now in operation whereby chairmen of Local Centres are ex officio members of the Council, free to attend meetings when they can do so, and in any case kept informed of what happens by the circulated minutes, is also good. A third important step—admittedly an experiment but a bold and constructive one—is the proposed summer meeting, which is to take place in Harrogate during May, 1940. If similar meetings can be successfully organised in turn by the various Local Centres they will afford members a unique opportunity of greeting each other, and should bring many new recruits to the Society. A glance at the accounts for the past year shows that the Society achieved only a small margin between income and expenditure. Increased activities, therefore, must be aided by a more than equivalent increase in membership—which should reach the 1,000 mark before long.

A Status Grade of Membership

The item in the report which will excite most interest, however, is the proposal to create a special "Status Grade of Membership," such as would entitle those with the requisite technical qualifications to the description "Fellow." It has always been understood—and this view was reaffirmed at a special meeting of the Society called to discuss outstanding questions affecting its future in 1935—that the Society is primarily a cultural rather than a professional one, an "Illuminating Engineering Society" but not a "Society of Illuminating Engineers." Nevertheless the council has decided, doubtless wisely, to give effect to the desire of some of its members for some form of recognition of technical skill and experience. The procedure now being explored will enable existing Corporate Members to apply for Fellowship. It will not affect the conditions of entry to the Society but it will doubtless afford an inducement to those within its ranks to become Corporate Members rather than Country Members or Associates. To carry the scheme into effect will involve a revision of the by-laws, but it is hoped to bring the scheme before members in the near future. There is no doubt that it will, when carried out, raise the status of illuminating engineering by affording for the first time a "hall mark" by which the expert illuminating engineer can be identified.

Testing Visibility

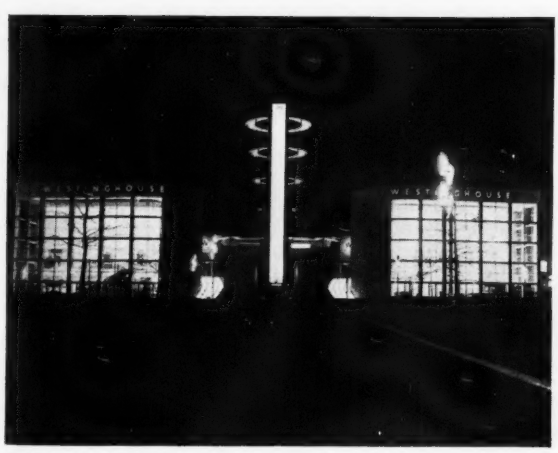
Seeing that lighting experts have not yet agreed on an entirely satisfactory definition of visibility, it is not surprising that the design of instruments intended to measure this important quality is beset by great difficulties. Some of these were discussed by C. Dunbar at a meeting of the I.E.S. Photometry Section on April 4. Such questions as the advantages and drawbacks of using wedges of graded absorption value which also produced a diffusing effect, the difficulty in assessing visibility for the large area simultaneously viewed by the eye—with an instrument that can only be directed in turn to particular spots, and the question whether results obtained for some particular task can be held to be relevant for other different processes were discussed. The latter point has a bearing on the—at first sight—rather fascinating plan of determining the illumination requirements of a process in terms of the amount of dimming that just makes it impossible to carry on. But there is always the fundamental difficulty that "threshold methods" only tell us the amount of reduction in brightness that is necessary to make a thing invisible—they do not measure the ease with which objects can be seen under practical conditions, which is what we aspire to know. We gather that Mr. Dunbar's paper and the ensuing discussion are to appear in the "Transactions" of the Society. Whilst it may be agreed that no present method of measurement is entirely satisfactory, there is no doubt that pioneers in this intricate field of work deserve great credit for their patience and ingenuity.

I.E.S. Midland Local Centre

Sub-Centre in Nottingham

In our last issue we referred to the formation of a sub-centre of the I.E.S. North Midland Local Centre, with headquarters at Sheffield. We understand that yet another sub-centre in the North Midland area—in Hull—is in course of formation. In the meantime the Midland Centre in its turn has developed a local centre for Nottingham, where an inaugural meeting was held on May 23. Mr. Frank Walker, a member of the Society of long standing, occupied the Chair and addresses were given by the President of the Society, Mr. Percy Good, and the Hon. Secretary (Mr. J. S. Dow) who had come up to Nottingham for the occasion. Following these informal talks, which summarised the aims and objects of the Society and reviewed recent developments, a formal resolution was moved and carried approving the formation of the sub-centre. Mr. F. Walker was elected chairman, and Mr. C. S. Caunt hon. secretary, and the names of a very representative committee, determined by ballot, were announced. The meeting was held in the lecture theatre of the Nottingham Gas Department, the modern design and equipment of which was much admired. The sub-centre has already secured over fifty applicants for membership, and as it is assured of the sympathetic co-operation of both the gas and electricity departments in Nottingham, it starts under very favourable auspices. The programme of meetings for the coming session is now in course of preparation.

A Novel Effect at the World's Fair



The World's Fair, New York, of which we have given some particulars in previous issues, is interesting for the novel lighting effects adopted at many of the pavilions. The picture above shows the Westinghouse Building. The "Singing Tower" in the centre is formed of a lighted pylon with a series of concentric rings and is 120 ft. high. Here there is a display of smoke, water, coloured light, and fireworks, all synchronised to music. In front of the tower stands the shrine of the "Time Capsule," flanked by the great halls of Power and "Electrical Living," each glass enclosed and rising to a height of 55 ft.

Greetings to Mr. Preston Millar

The snapshot above, showing Mr. Preston Millar (left) and Colonel Kenelm Edgcumbe (right) enjoying a joke together, was taken during an informal luncheon, when some of those intending to take part in the I.C.I. Congress in Holland were given an opportunity of meeting Mr. Millar on his first visit to London. He and Colonel Edgcumbe are past presidents of their respective Illuminating Engineering Societies, with headquarters in New York and London—and they both have the very rare distinction of being original members of our own Society, formed just thirty years ago! This fact was recalled at the annual general meeting on May 9 at which Mr. Millar seconded the vote of thanks for the presidential address.

The Lightest Stadium in the World

The artificial lighting of very large areas for the playing of games by night, which would have been dismissed a few years ago as impracticable, is now much more generally regarded as a feasible proposition. The change in outlook is due very largely to the recognition that such events have a "showman" value. When a good paying gate can be expected the expense of the lighting for an evening entertainment need not stand in the way. It has often been urged that in time to come professional football matches will be regularly played under cover and by artificial light—thus largely eliminating the vicissitudes of rain, mist, and fog, and the capricious uncertainty of winter daylight. A good example of the trend of development is afforded by the Philadelphia Athletics baseball club. According to the "Transactions" of the American Illuminating Engineering Society their ground in Shibe Park is to become "the brightest floodlighted stadium in the world." This was one of the first clubs in the American League to adopt night baseball. The contract for the new lighting stipulates that both spectators and players must be able to see the ball clearly both in the infield and the outfield. To meet this demand 780 1,500 watt lamps in 20 in. aluminium reflectors will be used. The lamps will be operated at 10 per cent. over their rated voltage (thus increasing the light output by 35 per cent.) and the illumination over the playing area will be of the order of 100 to 135 foot-candles—surely a record for any sports ground!

Apparatus for the Measurement of the Reflective Properties of Road Surfaces of Relatively Coarse Structure

By Dr. Ir. J. BERGMANS

(N.V. Philips' Gloeilampenfabrieken, Eindhoven, Holland, Lichttechnisch Laboratorium.)

In a dissertation* prepared by the author an apparatus was described for measuring the light reflected by road surfaces.

In the design of this apparatus allowance has been made for the following points, which are based on certain theoretical and practical considerations and described by the writer in chapters 1 to 4 of the dissertation mentioned above. These considerations may be briefly summarised as follows:—

1. The apparatus must be so designed that the light reflected by the road surface under a very small angle with horizontal ($\pm$ 1°) can be measured with sufficient accuracy. This is necessary in connection with observations at a relatively great distance (250 feet and more), such as are essential in the case of fast traffic.

2. The "angle of interception" of the photometer must be sufficiently narrow, in view of the desirability of being able to establish, with wet roads as well as dry ones, the coefficients of brightness (quotient of brightness and illumination for a combination of lighting and viewing direction), and to determine whether these brightness coefficients are really properties of the road surface and therefore independent of the brightness distribution and size of the light-sources.

This "angle of interception" was defined in the dissertation (par. 7) as "the widest angle between the rays deviating most from the axial direction which are still included in the measurement."

It was found that an "angle of interception" of ten arc-minutes was sufficiently narrow to allow of establishing, for all lighting installations with light-sources of normal dimensions suspended at the usual height, whether or no the measured brightness coefficient was really a property of the road surface.

There was one restriction, however, namely that the direction of illumination should not make a

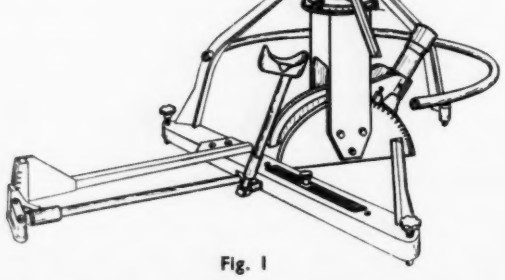


Fig. 1

wider angle than 80° with the normal to the road surface. If this angle is exceeded, a narrower "angle of interception" must be selected.

3. The apparatus must be transportable so that existing roads can be measured, and it must be easy to supervise the portions of the road reflection which is to be measured.

4. The structure of the portion of the road, the reflection from which is to be determined in one measurement, must be sufficiently typical of the road surface as a whole for the measured value to be used as a mean value for the road.

The apparatus described in the dissertation was found to be satisfactory in every respect for road surfaces having only a fine structure. The apparatus (see Fig. 1) works with a photographic photometer, in which way it is possible to operate quickly and with sufficient accuracy ($\pm$ 10 per cent.).

For road surfaces which may also have a coarse structure (clinkers, cobbles, ribbed surfaces, etc.), the great objection encountered is that the part of the

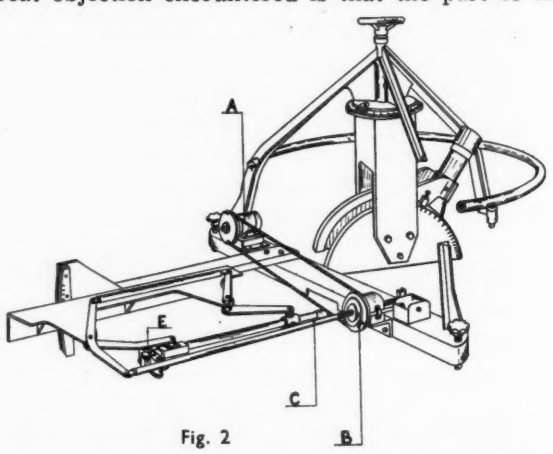


Fig. 2

surface area of which the reflection is determined at the same time, has a width of only 1.35 mm. for a length of $\pm$ 80 mm.

This surface area could be enlarged by increasing the distance at which the camera is placed (which is now 1.40 m.), but there is considerable objection to this from the standpoint with requirement 3. The apparatus would no longer be transportable, and the length of the section of the road surface on which the reflection was to be measured simultaneously would become too great. For example, in order thus to measure a width of 80 mm. it would be necessary to set up the camera at a distance of fully twenty-seven metres (about ninety feet). The length of the portion then tested would be 4.5 m.

These objections can be completely eliminated by suspending the camera with a parallel movement in which it is moved during exposure in a crosswise direction at a uniform speed.

Fig. 2 shows such a device. The motor (A) rotates via a variable transmission (string pulleys), a nut (B) causing the wire rod (C) to be pulled out or pushed in.

In order to obtain uniform movement during the exposure time the shutter is not opened before the mechanism is in uniform motion and is closed before motion stops. This is carried out in a simple manner by the mechanism itself, by means of a ridge (E) fitted to it which opens and closes the shutter.

With this apparatus it has been found possible to determine in a simple manner the brightness coefficients on road surfaces having quite a coarse structure (clinkers and cobbles), and also to deal successfully with ribbed surfaces.

* "Lichtreflectie door wegdekken" (Light Reflection by Road Surfaces). (Delft, June, 1938, published by the firm of Waltman, in Delft.) This dissertation is written in Dutch, whilst at the end of each chapter an extensive summary is given in English.

I.E.S. PRESIDENTIAL ADDRESS

by Percy Good, M.I.E.E., F.C.G.I.

A Summary of the Presidential Address delivered by Mr. Percy Good to the Illuminating Engineering Society at its Annual Meeting on May 9, 1939; this address appeared in full in the Transactions of the Society (Vol. IV, No. 5, May, 1939).

In the opening section of his presidential address, delivered before the Illuminating Engineering Society on May 9, Mr. Percy Good referred to the remarks of some previous presidents, remarking that all illustrated the wide field of interest covered by the Society, and stressed the importance of maintaining a high standard in all its activities.

Visit to Australia and New Zealand.

He explained that his own absence during the first half of the session was the result of an official invitation to visit Australia and New Zealand in order to discuss certain aspects of standardisation. The visit afforded an opportunity of making contact with the two Illuminating Engineering Societies in Victoria and New South Wales; the latter gave a dinner in his honour as president of the Society in London, and presented him with an album of photographs of lighting displays.

(In the course of the address Mr. Good threw on the screen lantern slides of a number of the most striking photographs in this album.)

Mr. Good reminded those present that it was the aim in Australia and New Zealand to attain a reasonably balanced condition of industry. Every effort was being made to develop the secondary industries, and in New Zealand the Government was taking steps to encourage this development. Those interested in the production of material necessary to give effect to the lighting progress now taking place would do well to bear this in mind.

The Conception of "Fellowship."

In the course of his discussion with the Illuminating Engineering Society in Melbourne and Sydney he had learned of the growing desire to have some recognised status for the illuminating engineer, and he had discussed the same topic with Mr. Preston Millar and Mr. D. W. Atwater, the President of the I.E.S. of America, which he visited on his way home. One result of these conversations was the suggestion, which it was hoped would receive favourable consideration, that the word "Fellow" should be adopted in all the English-speaking countries to indicate this special status of membership. Mr. Good explained that in New Zealand there was no Illuminating Engineering Society, but he had met there two members of our Society, Mr. J. C. Forsyth and Mr. C. E. Fuller, the former of whom was chairman of the Illumination Industry Committee of the New Zealand Standards Institute. This Committee took a keen interest in illumination, and had already issued its own code of Recommended Illumination Values.

Industrial Standardisation

Mr. Good then turned to the main topic of his address, Industrial Standardisation. He recalled that it was through his own association with the standardisation movement that he had become interested in the Illuminating Engineering Society, which had, since its inception, taken an active interest in this subject. There was no need to spend time in making out a case for it. Civilisation itself is the result of the application of standards in all its various phases of activity.

There is a tendency to conclude that "standardisation" is a process of freezing or the maintenance of sameness. There is, however, a much greater use of standards of quality and performance than of dimensional standards.

In order to illustrate steps in standardisation in connection with light the lecturer recalled the standard gas burner designed by Dr. Charles Carpenter, and the statement in 1869 by the Gas Referees in regard to the losses involved in the common use of burners of poor quality.

Standard Lamps and Lighting Equipment

Electricians, meantime, were establishing standard units and methods of measurement in their own field. The first British standard in the illumination field was that issued in 1906 for carbon filament electric lamps. In 1901 the British Standards Institution came into being. Its work in connection with illumination is mainly conducted under the Illumination Industry Committee, of which Colonel Edgcumbe is chairman. Mr. Good also explained the part taken by the Illuminating Engineering Society in the work of the various committees and their connection with the I.C.I. and with the Department for Scientific and Industrial Research (D.S.I.R.), which has done a great deal to assist the committees, on such subjects as the distribution of light from certain forms of reflectors, the quality of illuminating glassware, the characteristics of artificial daylight lamps, the relation between glare and visibility, etc.

In recent years there has been growing a demand for standards for the range of technical products purchased by the ordinary householder who cannot apply a standard and purchases in too small a quantity for inspection and testing to be justified. Until recent years specifications for electric lamps were used exclusively in the larger transactions, but they have now come into the above category.

This led to the important consideration that some form of guarantee mark should be provided. This idea is not new. Records can be found of fines in the twelfth century for adulteration of the rare metals. In the thirteenth century all gold and silver vessels were required to be marked under organised control, and in the nineteenth electroplated goods were so marked but without control, so that to-day the marks have little or no serious meaning.

Guarantee Marks Under Licence

In discussing the question how to prevent the misuse of a certification mark, Mr. Good remarked that prosecution is a difficult remedy to apply and offers little protection. The mark should imply an assurance by the maker that the article on which it appears conforms to the standard; or in the case of quantity-produced articles that the maker has in operation a system of control ensuring that a very high percentage does so. With this viewpoint the B.S.I. have evolved a system which has justified them in granting licences to some makers to use the B.S.I. mark. The system is being operated in over 100 factories and is already beyond the experimental stage. This use of a certification mark under a licence is a momentous step which puts the small buyer on a level with the large buyer.

When the experience of the B.S.I. was sought by Australia and New Zealand they had two alternatives—the free use of a mark, relying on the discovery of misuse after the goods had reached the market, or a system of licensing control. After the discussion the view reached by the B.S.I., that the only effective control is at the point of production, was accepted by both Dominions.

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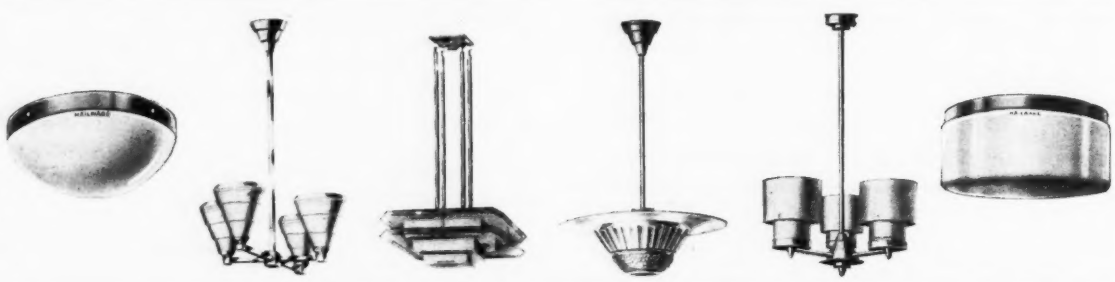

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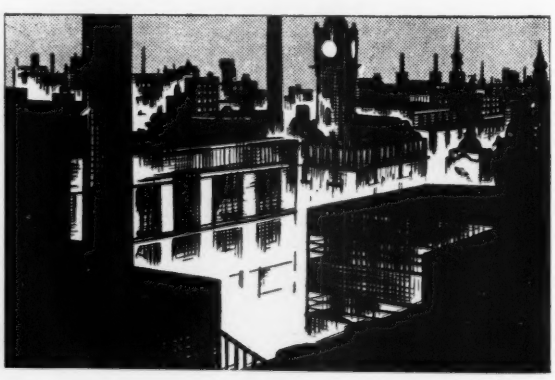
LIGHT IN DAILY LIFE

BY J. STEWART DOW

A Survey of Artificial Light in the Service of Mankind



Public Lighting by Electricity

London.—Street lighting is entirely electric in the boroughs of Battersea, Hackney, Hampstead, St. Marylebone, Shoreditch, and Stepney, and predominantly so in Bethnal Green, Fulham, Hammersmith, and Poplar. The most outstanding developments, perhaps, of recent years are the schemes carried out at Camberwell, and Deptford, to which reference has frequently been made in these notes.

Paignton.—There are now more than 1,000 electric street lamps in the Paignton urban area, the whole length of Torquay-road being lighted by 500-watt filament lamps in bowl refractor lanterns mounted at 25 feet. On the other side of Paignton is an outstanding example of sodium discharge lighting utilising 500-watt lamps in directional refractor fittings mounted at 25 feet. In this particular case tramway poles which were available have been used for the lighting standards. The visibility of this section of road is stated to be remarkably good, especially in view of the undulating nature of Totnes-road, which must have produced considerable difficulties in lighting distribution.

Newton-le-Willows.—At Newton-le-Willows and Newton-in-Makerfield, where electric street lighting is being adopted, sodium discharge lamps are used on the main roads. The greater part of this scheme is now complete.

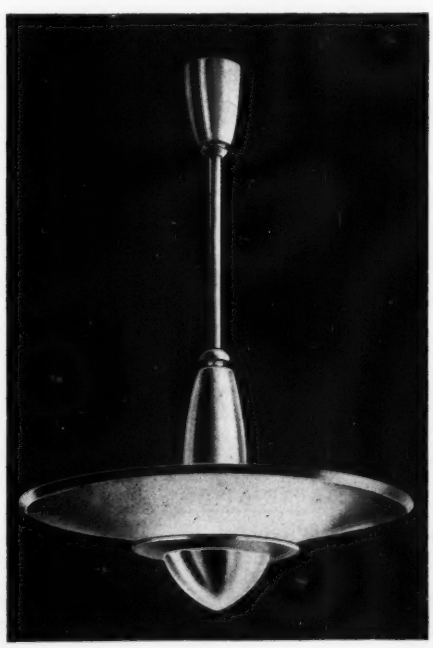
Sheffield.—An interesting use for street lighting lanterns with 500-watt lamps has been found at Sheffield, where six of them have been used to light a children's playground on one of the Corporation Housing Estates. The lanterns serve to provide a reasonable amount of light over the whole of the area, as well as an excellent intensity on the playing area, and it appears to be an economical method of lighting for a layout of this type. From the children's point of view the scheme has been so successful that it may well be the forerunner of further schemes on other estates. It is interesting to record that the first night the lights were in commission some 1,500 children arrived on the scene.

Beccles.—The Borough Council has decided to accept a tender of £773 per annum, submitted by the East Anglian Electric Supply Co., Ltd., for street lighting during seven years from August 1 next. The new agreement, which provides for general improvements and main-road lighting, is virtually a considerable reduction on the existing contract, which amounts to £829 2s. 6d. per annum.

Burgess Hill.—The Works and Town Planning Committee has recommended the adoption of electrically lighted standards in connection with the Valebridge-road reconstruction scheme.

"Anolier" Reflectors

We present below a view of the new "Anolier" type of reflector recently introduced by Benjamin Electric, Ltd., to which reference was made in our last issue (May, 1939, p. 102). There are available two types of this fitting, which



will accommodate lamps from 200 to 1,000 watts. A feature is the combination of the spread of light on the ceiling (effected mainly by the lower cup), but a small amount of light is directed on to the lower side of the main reflector, giving a pleasing appearance. The fittings are made of aluminium with Ali-Tal anodised finish.

Beautiful Waterways

This picturesque spot, with a waterfront strongly reminiscent of a small sea-port, lies on the Thames within the London Postal area.

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Literature on Lighting

(Abstracts of Recent Articles on Illumination and Photometry in the Technical Press)

(Continued from page 105, May, 1939.)

I.—RADIATION AND GENERAL PHYSICS.

151. The Radiation from High Pressure Mercury Vapour Discharge.

J. Kern and P. Schulz. Zeits. f. Techn. Phys., No. 5, pp. 148-152, May, 1939.

The influence of varying the pressure, loading, and discharge-tube bore on the visible and ultra-violet radiation output of the high-pressure mercury vapour discharge is plotted in a series of curves, and explained in terms of a previous article. A. E. S.

152. Near Infra-red Radiation.

L. S. Ickis and Howard Haynes. Magazine of Light, VIII., No. 3, pp. 11-13 and 36-38, April, 1939.

Details are given of the use of infra-red lamps for paint drying in industrial processes. The effect of the reflection of the surfaces of the fittings in which these lamps are used is discussed. C. A. M.

153. Drying with Near Infra-red Radiation.

L. S. Ickis and H. Haynes. G.E. Rev., 4, pp. 145-149, April, 1939.

Data presented show that, for most purposes, radiation of colour temperature 2,500 deg. K. is the best drying agent. Plant is described using tungsten lamps in special reflectors, and it is claimed that drying times are one-third or less of that required in processes previously used. J. S. S.

154. Sterilisation by Ultra-violet Radiation.

S. G. Hibben and P. W. Blackburn. Elect. Engineering, 57. Frank. Inst., J., 227, p. 460, April, 1939.

Development of methods of measuring abiotic radiation has enabled the study of the effect of radiations of different wavelengths on organisms to progress rapidly, and it has become possible to make a lamp, of the low-pressure mercury vapour discharge type, which, while emitting a negligible quantity of visible light, radiates just those ultra-violet radiations which are required for purposes of sterilisation. Some relative figures are given. S. S. B.

155. A New Effect in Luminescent Zinc Sulphide.

N. Riehl. Zeits. f. Techn. Phys., No. 5, pp. 152-155, May, 1939.

The light output of certain luminescent zinc sulphides is shown to increase more rapidly with increasing ultra-violet radiation than direct proportionality would imply. It is suggested that this is due to the greater proportion of energy which is dissipated as heat at low excitation, due to the longer time taken for the crystal to store up a quantum of energy. Confirmation is forthcoming from experiments carried out at higher temperatures. A. E. S.

156. Methods of Light Control.

C. E. Weitz and R. F. Cissell. Magazine of Light, VIII., No. 3, pp. 27-29 and 35, April, 1939.

The various methods of light modification, absorption, diffusion, reflection, refraction, and polarisation are discussed, with diagrams. C. A. M.

III.—SOURCES OF LIGHT.

157. Lighting Cost Comparisons.

Howard M. Sharp and J. F. Parsons. El. World, 111, p. 998, April 8, 1939.

The authors have derived curves relating the cost of lighting by high-pressure mercury vapour lamps and by fluorescent tubular lamps to that by standard filament lamps for varying cost of electrical energy, based on actual field studies of typical installations using normal fittings. All relevant factors, e.g., depreciation, maintenance, and operating costs, in addition to the relative luminous efficiencies of the bare sources, are considered. Details for preparing such a curve for any installation and any two light sources are given. S. S. B.

158. A More Efficient Cooper Hewitt Lamp.

R. C. Kelting and L. J. Buttolph. G.E. Rev., 4, pp. 160-166, April, 1936.

The construction, control gear, and performance of the latest type of Cooper Hewitt mercury vapour lamp is compared with earlier examples. Special fittings for the lamps are described, and the colour rendering obtainable is discussed. J. S. S.

IV.—LIGHTING EQUIPMENT.

159. Aluminium Reflectors.

J. D. Edwards. Am. Illum. Eng. Soc. Trans., 4, pp. 427-440, April, 1939.

The properties are described of "Alzak" aluminium reflectors, in which high reflectivity is obtained by anodically brightening the surface, which is protected by an oxide coating. Weathering tests carried out indicate that a loss of only 2 to 3 per cent. should occur after three years' exposure to severe conditions. Methods of cleaning and the effect of heating are discussed. J. S. S.

160. Engineering Aspects of Direct Lighting. Part II.—Transmitting Systems.

J. M. Ketch and L. G. Giani. Am. Illum. Eng. Soc. Trans., 4, pp. 411-426, April, 1939.

Tests are described on the efficiency, light distribution, and brightness of some direct lighting systems, in which control is given by transmitting media, such as diffusing glass or prismatic lens plates, without the use of louvres. Data drawn from the tests indicate the relative merit of these systems, and their application to different lighting problems. J. S. S.

161. Check-up on Film Cut-outs.

R. L. Biesele, Jr. El. World, 111, p. 1,036, April 8, 1939.

The importance of satisfactory operation of the film cut-out in series street lighting circuits is stressed. Some simple tests, in addition to more detailed ones, for determining the efficiency of operation of any type of cut-out are given. S. S. B.

V.—APPLICATIONS OF LIGHT.

162. Light and Architecture.

Anon. Am. Illum. Eng. Soc. Trans., 4, pp. 363-368, April, 1939.

Some architectural lighting schemes are described, with photographs. J. S. S.

163. Effects of Veiling Glare on Binocular Vision.

B. Babington Smith and R. W. Pickford. Nature, Vol. 143, No. 3,628, p. 804, May 13, 1939.

In an experiment on binocular vision through a veiling glare comparable with illuminated fog, it was found that

the effect of differential veiling glare on the apparent relative distances or sizes of objects seen through it is very variable from observer to observer. R. G. H.

164. Recommended Practice of Industrial Lighting.

Committee on Industrial and School Lighting. Am. Illum. Eng. Soc. Trans., 4, pp. 369-409, April, 1939.

A very complete summary is given of current recommendations for industrial lighting in America. J. S. S.

165. Air-Conditioned Hosiery Mill.

Anon. Magazine of Light, VIII., No. 3, pp. 22-23, April, 1939.

A description is given of a hosiery factory in America in which tubular fluorescent daylight lamps in single trough reflectors are used for general lighting. Values of 50 ft.c. on the working plane are obtained. C. A. M.

166. Industrial Lighting on a Trading Estate.

Anon. El. Times, 95, p. 571, April 13, 1939.

H.P.M.V. discharge lamps have been used in a large assembly bay to give a measured illumination of 8.5 ft.c. after six months' service. In the drawing office special large-area fittings are used to give an illumination of 25 ft.c. using 150-watt bowl silvered lamps. W. R. S.

167. Fluorescent Factory Lighting.

Anon. El. Rev., Vol. CXXIV., No. 3,026, p. 674, May 12, 1939.

A motor-body factory has been equipped with 400-watt fluorescent lamps, to give an average illumination of 20 ft.c. with a diversity ratio of 1.21 to 1. R. G. H.

168. Modern Lighting for a Modern Press.

W. S. Mowry. El. World, 111, p. 1,044, April 8, 1939.

A special lighting system has been devised for the lighting of a newspaper pressroom, using filament lamps in projectors at ceiling height and fluorescent lamps inside the press. The projectors provide general directional lighting of an intensity of 12 to 15 ft.c., while the same order of illumination is provided by the localised lighting. Full details are given. S. S. B.

169. Utility Sales Floor with 100 foot-candles.

H. G. Clum. El. World, 111, p. 1,048, April 8, 1939.

Illumination intensities in excess of 100 ft.c. are used in an American power company's sales room. Totally indirect combination mercury vapour-tungsten filament lamp units are used to provide general lighting to a level of 90 to 95 ft.c., while directional lens units give intensities of 125 ft.c. on display areas. S. S. B.

170. Lighting for Jewellery.

W. J. Eby. Magazine of Light, VIII., No. 3, pp. 16-17, April, 1939.

Two instances are given of lighting in jewellers' shops where successful results have been obtained by the combination of light from fluorescent lamps and incandescent lamps. C. A. M.

171. One-piece Surface on New Dispatching Board.

P. L. Peterson and W. S. Mowry. El. World, 111, p. 1,160, April 22, 1939.

The authors describe a dispatching board for electricity distribution and control, made from sheets of aluminium welded into one piece. Special attention was given to the lighting of the board. Indirect general lighting is supplied, but the lighting of the board itself is by means of prismatic lens plates, with the lamps offset to give a fanned beam of light, half the lamps lighting the upper half of the board and half the lower part of the board. An illumination of 35 ft.c. with a diversity of only 3 to 4 is claimed. S. S. B.

172. The Camera Reports.

Anon. El. Times, 95, p. 561, April 13, 1939.

Gives a number of short, illustrated descriptions of H.P.M.V. lighting in an oil refinery, a laundry, and other installations. W. R. S.

173. The Applications of Electric Discharge Lamps to Photographic Processes.

H. J. A. Turner. G.E.C. Journal, X., No. 2, pp. 93-105, May, 1939.

A discussion is given on the use of mercury and other electric discharge lamps for general photographic requirements. C. A. M.

174. Floodlighting Playgrounds.

Anon. El. Rev., Vol. CXXIV., No. 3,203, p. 540, April 14, 1939.

The report prepared by the National Fitness Council on floodlighting playgrounds contends that there is no evidence to justify the fear that such lighting may injure young eyesight. Details of some installations are given in the report, and costs are discussed. R. G. H.

175. Projection at the New York World's Fair.

F. E. Carlson. Magazine of Light, VIII., No. 3, pp. 7-10, April, 1939.

A description is given of the light projection equipment at the New York World's Fair. Specially designed lamps of 2,500 watts are used with air cooling around the lamp. C. A. M.

176. Electricity for Treasure Island.

William P. Bear, William R. van Bokkelen, and Wayne Snowden. Elect. Engineering, 58, p. 149, April, 1939.

Details are given of the electricity supply to the Golden Gate Exhibition at San Francisco, with special reference to the lighting effects. Fluorescent lamps and materials are used extensively, in addition to filament lamp units, and colour is the predominant note. The application of different types of units and the effects obtained are described. S. S. B.

Sodium Street Lighting at Eston

The installation of "Philora" sodium electric discharge lamps illustrated below, at Eston, North Yorkshire, is interesting for the fact that the lights are mounted on one side of the roadway only, where they are attached to the existing trolley-bus poles. Not-

withstanding this fact, the conditions of illumination over the entire surface of the roadway are considered very good. The 150-w. lamps are mounted in "Revo" silvered mirror reflectors 21 ft. 6 in. high, and are spaced at intervals of 120 ft. along main roads and at 240 ft. intervals on others. These roads vary in width from 30 to 40 ft. and are treated with tar-mac. dressing.

Recent Patents

(Abstracts of recent Patents on Illumination & Photometry.)

No. 501,914. "Apparatus for Illumination in Coal Mines and other Explosive Atmospheres."

Fodor, J. Dated June 3, 1937, *May* 26, 1938. (*Cognate Applications.*)

This specification covers an illuminating arrangement for use in explosive atmospheres comprising a high-frequency generator enclosed within a flame-proof casing and producing an external electric field which excites a luminous discharge-tube arranged close to the casing and energised solely by the field.

No. 502,051. "Improvements in Illuminating Means for the Transmission of Television and the Like."

The General Electric Company, Ltd., and Espley, D. C. Dated November 2, 1937.

In order to fill the field to be illuminated, such as a gate, a high-pressure metal vapour discharge lamp is combined with a condenser having different focal lengths in two planes at right angles to each other, the plane in which the magnification of the source is a maximum being perpendicular to the axis of the discharge column.

No. 502,321. "Improvements in Electric Discharge Tubes."

N. V. Philips Gloeilampenfabrieken. Dated July 9, 1937. (*Convention, Germany.*)

This specification relates to high-pressure discharge tubes using a vapour of a difficultly vapourisable metal such as cadmium or zinc, and its object is mainly to avoid condensation of the vapour in the cool parts of the tube behind the electrodes near the seals. To this end the tube has solid electrodes, and the space between the seal of each electrode and the end of the electrode facing the discharge is filled with the vapourisable metal so that the electrode end extends from the metal for a distance less than 4 mm.

No. 502,367. "Improvements in Combinations of Electric Discharge Lamps and Electric Incandescent Lamps."

The General Electric Company, Ltd. (*Communicated by Patent Treuhand Gesellschaft für Elektrische Glühlampen m.b.H.*) *Dated September* 27, 1937.

In order to produce light having better continuity of spectrum than is produced by the usual combination of a sodium vapour lamp and incandescent filament lamp with an efficiency higher than that of the incandescent filament lamp but lower than that of the usual combination, according to this specification, a discharge lamp producing the sodium spectrum and an incandescent filament are so proportioned that voltage across the incandescent filament is greater than, preferably two to five times, the voltage across the discharge of the discharge lamp.

No. 502,566. "Improvements in and Relating to Electric Battery Lamps."

The General Electric Company, Ltd., and Richards, S. W. Dated August 16, 1937.

According to this specification, a flame-proof electric battery lamp or torch has a rigid switch handle, extending through an aperture in the lamp or torch casing and co-operating with rigid parts of the casing adjacent to the aperture to form a labyrinth gland, and producing a relatively long, tortuous passage from the exterior to the interior of the casing.

No. 502,572. "Improvements in and Relating to Illuminated Signs."

Molina, E., and Molina, M. Dated September 23, 1937.

This specification describes a sign construction having at least one pair of mutually insulated electrodes, between which a high-frequency potential difference is maintained. The conductors are of grid form and are mounted upon a support so that gas-filled discharged tubes may be placed near to, but not in, electrical connection with the electrodes and will be illuminated by induction.

No. 502,575. "Improvements in Light Projectors."

Anciens Etablissements Sautter-Harle. Dated December 31, 1936. (*Convention, Belgium.*)

This specification describes a projector for producing a concentrated beam of light, but to be capable of producing a variable divergence in one transverse direction of the beam to provide a beam of flat or oval cross-section. The projector comprises a reflector, consisting of several parts carried by members pivoted mounted on different axes, and operated to pivot simultaneously by a single operating member. The pivot axes of the members may be parallel to the axis of the reflector as a whole or they may meet at its focus.

No. 502,585. "Improvements in Sources of Light Comprising Electric Discharge Lamps."

The General Electric Company, Ltd. (*Communicated by Patent Treuhand Gesellschaft für Elektrische Glühlampen m.b.H.*) *Dated March* 9, 1938.

This specification describes a lighting arrangement for avoiding flicker, comprising a number of high-pressure mercury vapour lamps, one terminal of each of which is connected by a common incandescent filament. The other ends of the mercury vapour lamps are supplied with alternating currents, displaced in phase relative to each other, all of which alternating currents pass through the filament.

No. 503,331. "Improvements in Sources of Light for Optical Projection Apparatus."

The General Electric Company, Ltd., and Francis, V. J., and Waldram, J. M. Dated October 4, 1937, *October* 18, 1937. (*Cognate Applications.*)

This specification describes an arrangement for filling a field, such as a gate of a cinematograph projector or an aperture of the projection objective, in which a high-pressure metal vapour discharge lamp of brightness greatly exceeding 1,500 candles/c.m.^{2} is fixed relatively to an optical system, which forms a greatly magnified virtual image of the discharge column in the position which would be occupied by the plane of a projection-type incandescent lamp.

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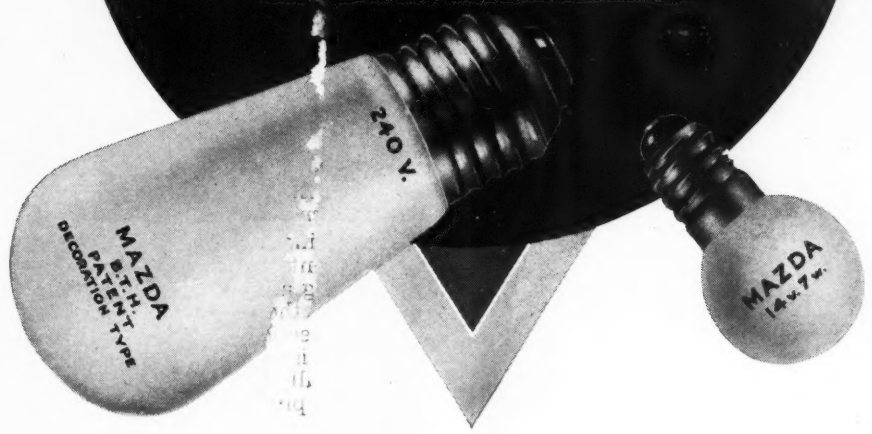

THEY are particularly recommended to public authorities and entertainment companies who require large quantities of coloured lamps for the decorative or festive lighting of PARKS, PROMENADES, PIERS, AMUSEMENT PARKS, HOLIDAY CAMPS, FAIRS, BANDSTANDS, BATHING POOLS, GARDENS, ROAD HOUSES, DANCE HALLS, etc.

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Gas Lighting at the new Twickenham Swimming Pool

The illustration shows gas floodlighting installed at Hampton public open-air bath by the Twickenham Borough Council. Nine lamps, each with eight mantles, are mounted on concrete columns with bracket arms, at a height of 13 ft. 6 in. from the floor. Distance control is an integral part of the installation, the lamps being controlled in two batteries.

The size of the Hampton bath, exclusive of the surround, is 120 ft. by 30 ft.; the lamps not only provide ample illumination for bathers, but give sufficient light in the dressing rooms and the sun-bathing area to obviate the need for extra lamps here. The noticeable amount of warmth given out by the lamps is appreciated, too, by the bathers. The running costs of this installation when all nine lamps are alight are approximately 7½d. per hour, a very small expenditure for the benefits obtained.

Public Lighting With Gas

There are 1,954 gas lamps in commission in Wigan, where the agreement between the County Borough and the Gas Department has been renewed for 1939-40.

The Retford Borough Council has renewed its contract and is initiating improvements in the lighting, which is maintained by about 300 lamps. Lamps of higher candle-power have already been substituted for all but three of the two-mantle lamps.

Under a ten-year agreement the Monk Fryston Parish Council is introducing gas lighting for the first time into this little Yorkshire village.

In 1937 the Broadway Parish Council installed gas lighting for the first time. The new contract was for a period of three years, expiring in 1940. So satisfied, however, is the Council with the new lighting system that the term of the contract has been doubled, and it will run until October, 1943.

Another Cotswold beauty spot, Chipping Campden, has followed Broadway's example. The decision to adopt gas lighting was arrived at at a recent parish meeting.

The Whitchurch Parish Council, Glamorgan, has installed modern gas lighting at a traffic roundabout in its area. Two eight-mantle lamps with automatic ignition are used, mounted on 25-ft. standards.

The St. Helen's Corporation has received sanction from the Ministry of Health for a loan of £5,597 for street lighting improvements. The lamp being adopted is the four-mantle suspension type, with a stainless-steel back reflector. The spacing of lamps varies from between 53 ft. and 64 ft. on bends to 85 ft. on straight stretches of road. When the first year's work has been completed 521 of these new lamps will have been installed. The lamps will be 15 ft. high—the approved maximum height in Group "B" Specification. Lamps will be attached by brackets to the existing trolley-bus poles.

Morley Corporation has entered into a ten-year agreement for the lighting by gas of the Old Borough of Morley. About 722 lamps are in commission, and schemes of new and improved lighting are being put in hand.

More than 600 lamps are covered by a renewal of its lighting contract by the Abertillery U.D.C.

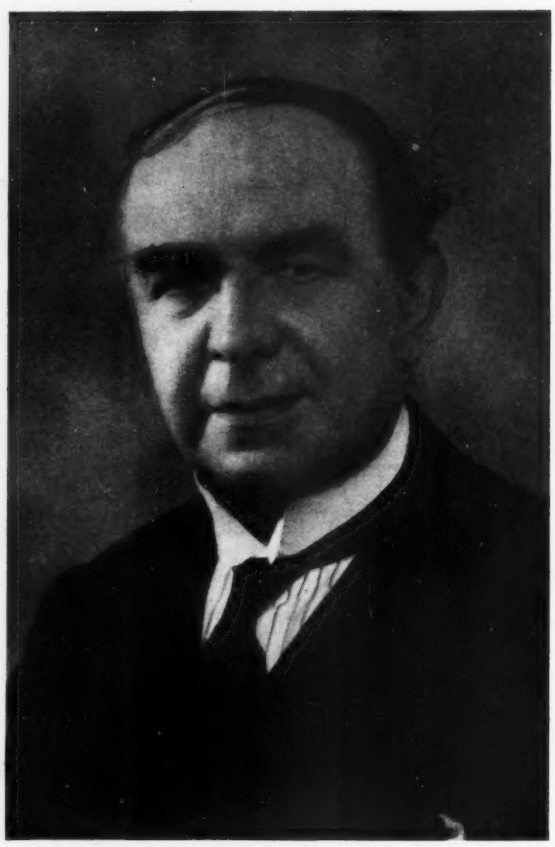
The Paisley Corporation Gas Department has been called upon to light Potterhill, Cardonald West, and Elderslie during the current lighting season. About 240 lamps are in commission.

Willenhall U.D.C. has entered into a five-year contract for gas lighting on main roads in the district, and has also renewed its agreement with the local gas undertaking for the lighting of subsidiary roads. In all, a total of 572 lamps is in use. The lighting on the main roads is to be raised to a higher standard.

Other recent renewals relate to: Ballymena, Buckley, Coleraine, Dalkeith, Draycott, Dungannon (three years) Kirkintilloch, Prestatyn, Reigate, Rothesay, Saltcoates (five years), Sedbergh (five years), Sheringham (seven years), and Treharris (three years).

Obituary

John Wyatt Ife



We regret to announce the death of Mr. John Wyatt Ife, aged seventy-three, on May 27. Mr. Ife spent the greater part of his business life with Holophane, Ltd., of which he was secretary when he retired in 1934. He was one of the original members of the Illuminating Engineering Society, in the formation of which he took an active part, of which he was honorary treasurer for many years, and of which he became a life member. Those who came into contact with Mr. Ife learned to appreciate his conscientious and kindly disposition, and the news of his death will be received with general regret.

Lighting by Luminescence

by

André Claude

(Summary of an article published in the Bulletin of the Société Française des Électriciens for April, 1939.)

1.—The Electro-luminescence of Gases and Vapours.

The problem of converting the Geissler tube into a practical and efficient source of light has for many years occupied the attention of numerous investigators, notably E. Becquerel, Moore, G. Claude, and Langmuir. For a long time, however, little progress was made, and in 1908 A. Berthier, in his book "L'Eclairage électrique" (1), quoted measurements of efficiency made by A. Witz, who concluded that this was "a ruinous form of lighting."

It might seem that in this subject of electro-luminescence our modern theories of the structure of matter and of the mechanism by which radiant energy is produced should enable technical development to make rapid progress, but in actual fact the phenomena of the electric discharge in gases and vapours are extremely complex. The number of variables is large: they include the form of the tube, the nature of the electrodes, the nature and pressure of the gas, the type of current supplied, the auxiliary apparatus used for starting and stabilising the discharge, etc. Further, a modern electric lamp has to possess a combination of characteristics—life, luminous efficiency, spectral quality of the light emitted, power, simplicity of operation—which it is difficult to obtain *all at once*. This, no doubt, is the reason why progress has been so slow.

Discharge Tubes Containing the Rare Gases.—There is no doubt that, after the mercury tubes of Cooper Hewitt and the nitrogen and carbon dioxide tubes of Moore, the greatest progress was made by M. Georges Claude, who in 1910 produced valveless neon tubes having a long life and high luminous efficiency (2) (3), and low-pressure mercury tubes in which a small amount of mercury was introduced into a neon tube (4). The present annual world production of such tubes is several millions of metres.

The rare gases and mercury at low pressure emit, under ordinary conditions, what is essentially a line spectrum. They are coloured sources of linear form. This, while advantageous for advertising or for decorative purposes, is a drawback for general lighting where what is required is a white light and a lamp which operates on ordinary supply voltages.

A means of achieving these ends, which was first indicated by Küch and Retschinsky in 1906 (5) and has since been developed, notably by the Dutch firm of Philips, consists in producing and maintaining very high pressures of mercury in a mercury tube.

Spark Spectra of the Rare Gases.—Our own researches on the production of a white light consisted at first in attempts to make use of the light emission of the rare gases, more particularly kryton and xenon, when radiating under special conditions of electric excitation. Thus xenon, which ordinarily gives but a faint bluish glow, may, when subjected to a highly condensed discharge, be made to emit a bright white light. At low pressures the spectra obtained in this way show a mass of lines close together. These spark spectra were observed in 1924 by MM. Eugène and Léon Bloch and M. Déjardin (6) who excited the gas by induction, using pressures less than 1 mm. of mercury and an oscillatory discharge.

Conditions for Producing Spark Spectra.—In 1928 M. Bay described the excitation of discharge tubes by means of a series of very brief "pulses" of current at the frequency of an ordinary power supply. These pulses can be obtained by means of a spark gap or by placing in circuit a thermionic valve, the voltage on the grid of which is adjusted to give the desired succession of pulses of current. In this way, although the instantaneous values of current may be extremely high, the mean current is of a value compatible with a satisfactory life of the tube. Even at low gas pressures very intense currents are necessary to produce spark spectra. Using continuous current we showed in 1931, with M. Delrieu (11), that for xenon a current density of the order of 50 to 100 amps/cm^2 was necessary when the pressure was 0.5 mm. of mercury.

For the stroborama of MM. Seguin (12) the xenon tube has been successfully employed in industry since 1933 (13), and, in view of the very actinic quality of the light produced, it has been applied to ultra-violet cinematography at frequencies of 10,000 to 20,000 per sec. (13).

Continuous Spectra of the Rare Gases.—Various workers, notably Hopfield (14), Laporte (15), McCallum (16), and Déjardin (17), have described the emission of continuous spectra by the rare gases under certain experimental conditions. More particularly McCallum, in the cases of argon and krypton, has stated that the conditions most favourable to the production of a continuous spectrum are large diameters, high pressures, and low current densities. We have resumed former work (18) on xenon, especially on the effect of pressure and current density.

Spark Spectra and Continuous Background for Xenon.—The results we have obtained may be summarised as follows:

(a) Within the range of pressures studied, viz., 1 to 60 mm. of mercury, and for ordinary diameters (0.5 to 60 mm.), the continuous background increases in intensity as the pressure is raised, no matter what the current density (Fig. 1).

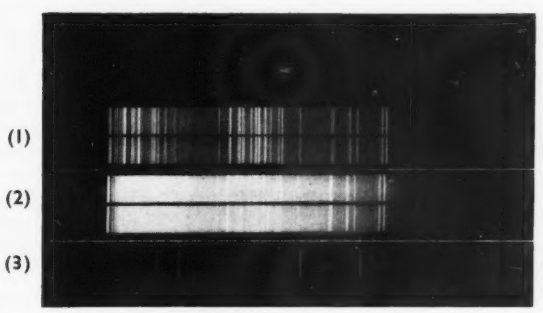


Fig. 1. Arc Spectra for Xenon (Visible Region). Internal diameter of tube, 10 mm. Current 100 mA.
(1) Pressure of Xenon, 4 mm. (Hg.).
(2) ,, ,, 10 mm. (Hg.).
(3) Spectrum of Mercury, for reference.

(b) Within the same range of pressures and diameters, the different spark spectra of xenon may always be produced if the current density is *sufficiently* increased.

Present Limitations on the Application of the Electro-Luminescence of the Rare Gases to Lighting.—To sum up it may be said that, although the spectral distribution of the rare gases may be greatly

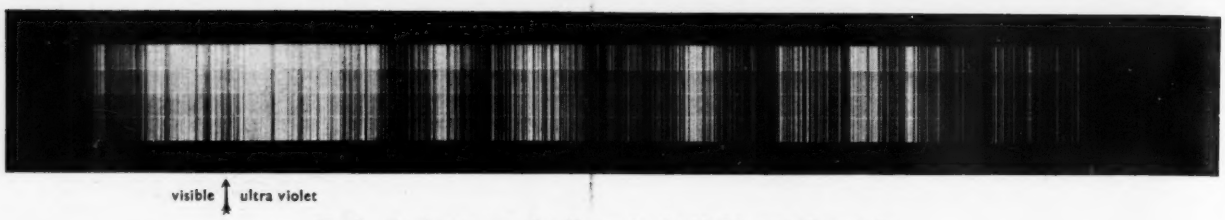


Fig. 2. Spark spectrum for Xenon in the Visible and Ultra-violet.

improved by using a pulsating current, and although the applications in stroboscopic apparatus, cinematography, signalling, and actinotherapy ([19]) are extremely interesting, the problem of general lighting remains unsolved. In fact:

(i) Spectrographs such as that shown in Fig. 2 indicate that there is always a large amout of *lost* radiation, not only in the infra-red, but also throughout the ultra-violet. The luminous efficiency is low: 15 lumens per watt at most.

(ii) Stroboscopic effects resulting from a pulsating current are objectionable.

(iii) The apparatus required is clumsy and complicated.

II.—Electro-luminescent Tubes with Internal Coatings of Photo-luminescent Solids.

HISTORY.—Ideally, as M. Georges Claude pointed out in 1911 ([20]), all the energy absorbed in the production of light should re-appear in the form of light; actually, the possibility of using luminescent substances to convert into visible radiation a large part of the ultra-violet radiated by discharge tubes opens the way to a notable increase in luminous efficiency. Further, the infinite variety available in the emission spectra of luminescent substances encourages the hope that it may be possible to obtain light of any desired spectral distribution and, in particular, a white light.

The luminescent material may be placed either inside or outside the discharge tube or it may be incorporated in the glass of the tube itself. Lamps in which the material was outside the tube were described by Steinmetz in 1902 and Shott (see ref. (1), p. 228). In 1923 M. Jacques Risler ([21]) described tubes coated externally with zinc sulphide, while H. G. Jenkins, J. W. Ryde, and G. H. Wilson use a zinc cadmium sulphide activated with copper. J. T. Randall ([22]) has just described a lamp which consists of a bulb coated internally with the luminescent material and containing a high-pressure mercury tube.

Although Fleming in 1904 used glass "impregnated" with uranium, Fischer in 1933 was the first to obtain practical results from the use of luminescent materials in the substance of the glass itself. He employed silicate glasses as free as possible from iron and containing combinations of the heavy metals (U, Cu, Pb, Mn or the rare earths). Further progress, at any rate as regards luminous efficiency, has recently been made by the use of phosphate glasses containing a very low concentration of tin. Dr. Seidler finds ([25]) that the light emission is three times as great as that obtainable with the best white fluorescent glasses hitherto available commercially.

The third arrangement, in which the luminescent material is inside the tube, is that which we have studied especially. It seems to have been used for the first time by E. Becquerel.

TUBES COATED INTERNALLY WITH LUMINESCENT MATERIALS.—Becquerel, in a paper published in 1859 ([24]) and later in his book "La Lumière" ([25]), described low-pressure (1—2 mm.) discharge tubes containing various luminescent solids in fragments or in

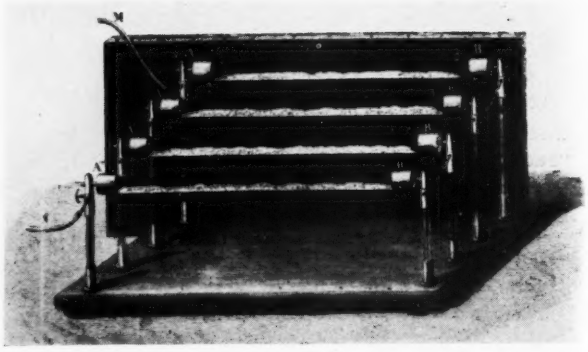


Fig 3. An illustration taken from "La Lumière" (Becquerel, 1867) showing apparatus for the study of fluorescent materials in discharge tubes.

powder form. He suggested the preparation of tubes or bulbs in which a thin coating of such material was stuck to the inner surface of the glass. No attempt to apply this idea seems to have been made until 1910, when MM. Urbain, Feige, and Clair Scal patented a "lamp" consisting of a Geissler tube (containing a gas at low pressure, particularly a rare gas from the atmosphere) on the inside surface of which was an adherent coating of a phosphorescent sulphide.

However, this patent had, as far as I am aware, no practical result. Returning to the subject in 1923, M. Jacques Risler concluded from his experiments that the use of an internal coating suffered from the grave difficulties that the adhesive varnish not only acted as an absorbing screen but gave off vapour which made it difficult to exhaust the tube or keep the pressure constant ([21]), ([26]).

What, then, was to be done? Must the attempt to use an internal coating be abandoned? Following the dictum of M. Georges Claude that "in technical matters one must never despair, never acknowledge defeat by an obstacle which is not grounded in something that theory declares to be impossible" ([27]), we set out to overcome the difficulties little by little, until we finally obtained the results for which we had hoped. On December 27, 1933, M. Georges Claude was able to communicate to the Académie des Sciences ([28]) the completion of the first stage of our labours in which we had been helped and encouraged by Koch's results and which were carried out with the valuable collaboration of MM. Delrieu and Besson. The tubes which we had developed operated on high voltages, and were at once applied, not only for advertising and decorative purposes but also to general lighting, for which purposes a neon tube was used with a green fluorescent tube ([29]). Since then our intensive researches have enabled us to make continuous improvements. From 1936 it has been possible to obtain "white light" from a single tube. To-day the luminous efficiencies are much greater than those of the best filament lamps.

BEST CONDITIONS OF EXCITATION.—The luminescent material should be carefully "adjusted" to suit the gas and the operating conditions of the tube. Jenkins has given the best conditions for the excitation of

zinc silicates in neon ([30]); we have shown that krypton and xenon are also capable of exciting certain fluorescent substances ([29]).

For krypton and xenon the feebly luminous spectrum of the arc does not affect the continuous spectrum due to the fluorescence; the spark spectrum, however, makes a valuable addition to it and improves the luminous efficiency. The operation of tubes containing the rare gases is not affected by the external temperature. Generally speaking, for all the rare gases, the luminescence rapidly reaches saturation at low current densities, although this effect is less pronounced the greater the tube diameter.

In contrast to this, the tubes containing rare gases mixed with mercury vapour at low pressure give much better results. Saturation is scarcely noticeable. Tubes of 20 mm. diameter can operate at currents up to 0.3 amps. Greater densities increase the pressure of the mercury vapour and give inferior results. It may be said that, at the present stage of development, the use of *internal* coatings of luminescent material is impossible in tubes containing mercury at high pressures. At low pressures, on the other hand, the luminous efficiencies reach very high values, over 50 lumens per watt in the positive column. Moreover, it is possible to obtain intense emission with continuous spectra having extremely varied energy distributions, spectra which can be modified at will to obtain a coloured light or white ([31]), ([32]).

MECHANISM OF THE EXCITATION.—M. Marcel Servigne has shown experimentally that in the case of the tubes containing the rare gases and mercury it is the ultra-violet radiation that is principally effective in producing luminescence ([33]). A Ruttenauer has shown ([34]) that in the case of neon it is the resonance lines situated in the extreme ultra-violet (736—744 Å) that count. We have found that the same holds for argon (1048—1066), krypton (1236—1165), xenon (1470—1295), and mercury (2537). This knowledge serves as a guide in the development of a luminescent material which is to be especially sensitive in the region of the most active radiations.

NATURE OF THE LUMINISCENT MATERIALS. FLUORESCENCE. PHOSPHORESCENCE.—The luminescent substances generally used are tungstates and silicates. Phosphorescent materials are preferable to those showing fluorescence, because the stroboscopic effects are reduced when the tube is supplied with alternating current, and the tube may be run at a higher temperature. The theory of the difference between the two classes of luminescence has been studied by J. and F. Perrin ([35]), and can be used to explain the observed behaviour of various substances ([36]).

DEVELOPMENT OF LUMINESCENT SUBSTANCES FOR INTERNALLY COATED DISCHARGE TUBES.—While such luminescent materials as the tungstates and silicates are usually unaffected by the rare or "inert" gases, in the case of mercury they generally show a chemical change resulting in a progressive loss of luminescence. Among the various means which may be adopted to prevent this action, there is one which we have found to give remarkable results. This process consists essentially in "stabilising" the luminescent material by adding to it in the crystalline state and under suitable conditions certain minerals which have a high melting point and which, in the thickness used, are transparent both to the exciting and to the emitted radiation. The combined effect of the processes employed is not only to prevent any change in the luminescent materials but also to maintain the luminous efficiency at a high value throughout life. Fig. 4 shows results which we have already achieved. Curve 60 refers to a tungstate and curve 511.4 to a silicate. The fall of luminous efficiency in the first 1,000 hours is comparable with that of a tungsten lamp, and subsequently it is about 2 per cent. per 1,000 hours.

The process of manufacture depends on the constancy of the chemicals used, and their purity is controlled spectroscopically. After appropriate treatment in the electric furnace, the powder is examined for size of grain and for external structure by microphotography. Its internal structure is determined by X-ray examination. Then trial tubes are coated internally with the material, and the spectral energy distribution of the light emitted by these tubes is studied with the spectrograph. The trial tubes are then put on life test to ascertain the maintenance of the luminous efficiency.

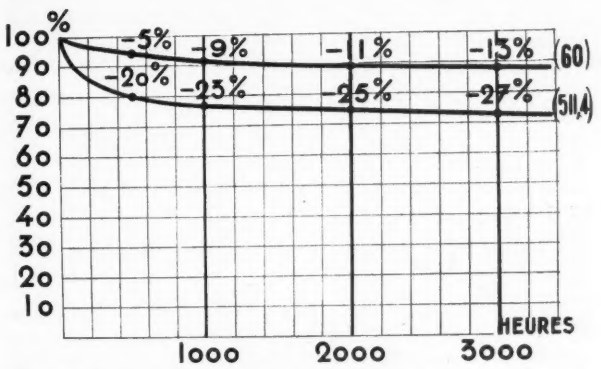


Fig. 4. Fluorescent Tubes: Data showing variation in efficiency with time in the case of two fluorescing materials.

III.—Operation of Electro-Luminescent Tubes on any Customary Voltage of Supply.

A PROBLEM.—We have just seen that luminescent materials may be successfully applied as internal coatings to discharge tubes containing the rare gases or mercury at low pressure, but such tubes operate at high voltages and therefore necessitate the use of much auxiliary equipment.

We therefore set ourselves the task of developing tubes of this kind which could be used on the customary supply voltages of 110 to 220 volts, *without any modification of the two-wire method of supply usual for tungsten filament lamps.*

RUNNING CONDITIONS.—When a discharge tube containing rare gases and mercury vapour and having two similar electrodes is running on alternating current the voltage-current characteristic is negative (except in the case of certain tubes of special design). The tube must be stabilised with an impedance placed in series with it. A choke is used in preference to a resistance or a capacity. The power-factor is raised to about 0.9 by means of a condenser placed across the terminals of the supply. As the light emitted comes from the energy absorbed in the positive column the characteristics of the tube are chosen so that under running conditions the voltage across the terminals is as high and the fall of potential at the electrodes as low as possible. For a supply voltage of 110 the potential across the terminals of the tube is 60 to 70 volts. This gives a minimum loss in the choke and the condenser, while the loss at the electrodes is reduced by using thermo-emissive electrodes.

THERMO-EMISSIVE ELECTRODES.—The conductivity of gases in the neighbourhood of a hot body has been known for a long time, certainly since its mention by E. Becquerel in 1853 ([38, 39]). Moore seems to have been the first to suggest its application to discharge tubes in a patent of his, dated 1902, but he does not seem to have based his suggestion on the fundamental

discoveries which had been made shortly before that time by McClelland ([40]), J. J. Thomson ([41]), Richardson ([42]), or Wilson ([43]). Nevertheless, Moore determined the conditions necessary for the proper operation of the electrodes—conditions which remain valid to-day. Further, he anticipated Wehnelt in the use of the oxides of calcium, of magnesium, or of the rare earths for the production of electrodes which would not disintegrate during life.

After the self-heating electrode, Moore described, in a patent of 1905, the electrode which is heated by means of an auxiliary supply from the mains. These electrodes are metal filaments, both alike since they serve alternately as anode and cathode when the tube is operated on a.c.; the filling consists of a gas, or a vapour, pure or mixed, and the cathode fall of potential is greatly reduced. This is the prototype of the modern, low voltage discharge tube with heated electrodes.

THE PROBLEM OF STARTING-UP.—The tube described above, although it will run perfectly steadily on 110 volts, will not start at this voltage. Starting-up may be effected by means of a high-frequency discharge produced by auxiliary apparatus, but a much more simple device is to heat the electrodes by passing current through them from the mains. A contact, operated by means of a relay, cuts off the heating current as soon as the correct temperature is reached, and the supply voltage is then applied across the tube. This is the principle of the fluorescent tubes recently developed by the Lamp Development Laboratory of the American G.E.C. ([51]). The tubes now on the market in the U.S.A. seem, then, to be the first commercially produced discharge tubes with internal fluorescent coatings, operating on ordinary supply voltages ([52]).

The method employed for starting high voltage tubes is to apply an excess voltage (of the order of double the running voltage) across the tube. This scheme cannot, however, be used for low voltage tubes where the excess voltage necessary would be much more than double the running voltage. For a usual type of self-heating electrode, experiment shows that this voltage must be at least four times as great as the voltage across the tube. Further, the operation of starting includes the heating of the electrodes to the necessary temperature, by means of the discharge itself.

Under practical conditions, starting must not take more than a few seconds. During this short time the electrode is the seat of a series of important phenomena which have been described and analysed by Uyterhoeven ([53]) and Darrow ([54]). From our point of view, the vital phenomenon is the final one, viz., the change-over from the glow discharge, with abnormal cathode fall, to the arc discharge. During the passage of the glow discharge, the glow which surrounds the electrode forms a positive sheath separated from the electrode by a dark space in which the electrons are accelerated. If, during the very short time available for starting, the electrode has not reached a sufficiently high temperature to become emissive, it may be thought of as behaving like a cold electrode. The potential gradient then rises in the positive sheath until a discharge takes place across this pseudo-condenser. The higher the potential difference across the condenser the more likely is the discharge to produce cathode spots and undesirable rectifying effects.

"SENSITISED" ELECTRODES.—Our experiments have shown that thermo-emissive electrodes of the Wehnelt type, if properly designed, particularly as regards dimensions, the nature of the metal which supports the emissive material, and appropriate heat treatment in vacuo, enable the starting potential to be reduced from four to two and a half times the running voltage. Further, the current needed for quite rapid starting is of the same order as the normal operating current. Thus our electrodes fulfil the conditions laid down by Moore, viz., low cathode fall of potential, absence of emission of impurities during operation, and long life without disintegration.

With these "sensitised" electrodes not only are there no destructive cathode hot-spots or rectifying effects, but the apparatus needed for starting is of the simplest. The auxiliary apparatus (choke and condenser) needed for the satisfactory operation of the tube when running can, by means of appropriate tappings, provide the conditions necessary for starting up.

IV.—Fluorescent Discharge Tubes.

LUMINESCENCE AND INCANDESCENCE.—Tubes containing the rare gases or mercury at low pressure, constructed according to the principles of Section III. and coated internally with luminescent substances, as described in Section II., may be made for use as lamps operating on normal supply voltages and giving high luminous efficiencies ([55]).

PROTOTYPE "FLUORESCENT" DISCHARGE LAMP.—One of these "fluorescent" lamps which we have developed to the semi-commercial stage has the following characteristics: The tube is 46 cm. long and 25 mm. in diameter, and has a single-contact cap at each end. It can be run on 110 volts a.c., the auxiliary apparatus being inserted anywhere in the two leads connecting it to the supply network. The operating current is 0.25 amp., and the total consumption 15.9 watts, of which 2.6 watts is absorbed in the auxiliary apparatus. The power factor is 0.88 to 0.90.

For a white light, the luminous flux obtained is as much as 500 lumens, giving an efficiency of 30 lumens per watt (including losses). Thus the efficiency is much higher than that of tungsten filament lamps of comparable size; actually a 25 watt argon lamp gives about 9 lumens per watt, while a krypton lamp of the same size gives 12 lumens per watt.

LIFE: "FLUORESCENT" AND INCANDESCENT LAMPS COMPARED.—The life of "fluorescent" lamps does not depend on the luminous efficiency as in the case of filament lamps. We have already seen that the photo-luminescent material used for the internal coating of these discharge tubes retains its power of light emission, without serious loss, for thousands of hours. For filament lamps, however, the life is a very definite function of the efficiency, varying roughly as the inverse seventh power of that quantity. Thus, any improvement in the manufacture of such lamps may be used *at will* to increase either the life or the luminous efficiency.

The improvement due to the substitution of krypton for argon has so far been entirely used to increase the efficiency ([56]), e.g., for the 25 watt lamp (single-coil) it is raised from 9 to 12 lumens per watt, as mentioned above. The improvement might equally well be applied in increasing the life of the lamp from 1,000 to over 6,000 hours, leaving the efficiency at 9 l.p.w. The same remark applies to the coiled-coil lamp (see Fig. 5). Still further progress may be made, I am convinced, by the use of xenon, in spite of its extreme rarity ([57]).

It will be seen, then, that from the point of view of economy in use, the fluorescent lamp is in quite a different position, technically, from that of the filament lamp.

PRACTICAL USE OF "FLUORESCENT" DISCHARGE LAMPS.—Fig. 6 shows some "fluorescent" discharge lamps of the 16 watt rating, running on a 110 volt supply, together with their auxiliary apparatus, which includes a switch of the press-button type. Discharge lamps of this type can also be supplied directly from 220-volt a.c. mains, only a stabilising self-inductance being necessary for each lamp in this case. Fig. 7 shows diagrammatically the circuits for supply to several lamps fed from mains of these two voltages respectively.

Within the limits indicated by the technical principles which have been explained above, it is possible

to make tubes not only in a great variety of colours but also of different ratings. Tubes taking 25 watts and 9 watts have already been developed, in addition to the original 16 watt rating. Work now in progress indicates the possibility of making tubes of still higher and lower wattages. In particular, by increasing the diameter and the length, it is possible to construct tubes taking 100 to 200 watts, without raising the pressure of the mercury vapour, when the tube is running, above the low value most favourable to the production of photo-luminescence. Generally, the brightness of the tubes is of the order of 1.125 stilb (7.25 candles per sq. inch); this brightness is about one third of that of a 60 watt filament lamp in an opal bulb, and its value is such that the "fluorescent" discharge lamp may be used without the necessity for any surrounding diffuser to protect the eye. Finally, photo-luminescent materials may be advantageously employed for the internal coating of discharge tubes which take only a very small amount of power, e.g., on the bulbs of cathode-glow lamps.

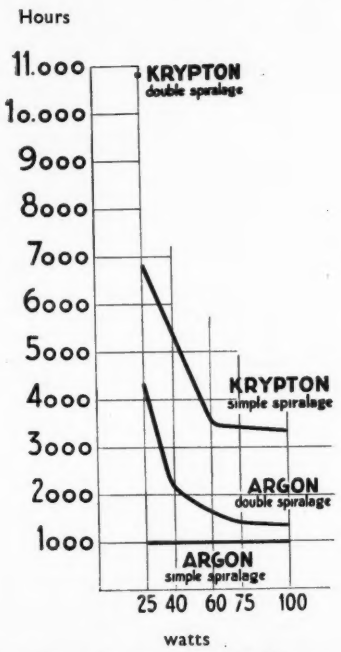


Fig. 5. Life of Incandescent Lamps of different types, as a function of the power and for equal luminous efficiency.

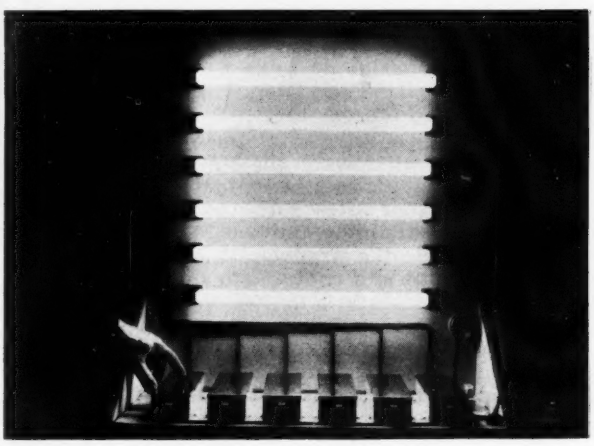


Fig. 6. Fluorescent Tubular Lamps operating at 110 volts.

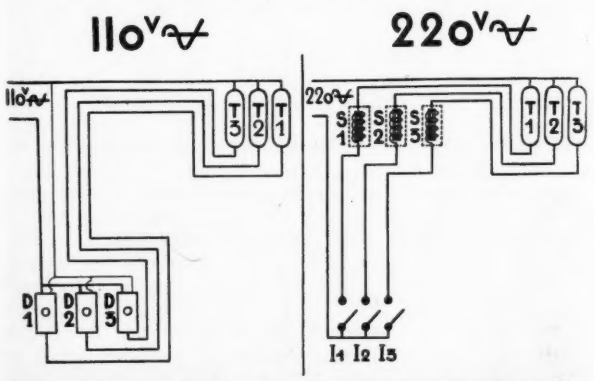


Fig. 7. Scheme of Circuits for several fluorescent lamps on 110 v. and 220 v. alternating circuits. T_1, T_2, T_3 fluorescent lamps; D_1, D_2, D_3 apparatus for operation on 110 v.; S_1, S_2, S_3 stabilising self-inductances to facilitate operation on 220 v.

The results so far obtained, taken together, seem to indicate that there are extensive applications for discharge lamps operating on ordinary low-voltage supplies and possessing a long life, lamps which, in order to obtain a more efficient conversion of electrical energy into visible light, employ an intimate combination of the phenomena of electro-luminescence in gases or vapours with those of the photo-luminescence of solids.

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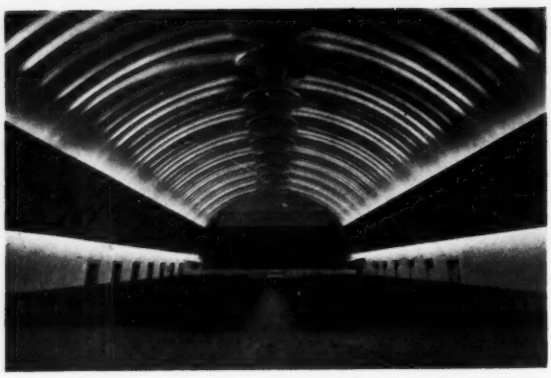
NOTES ON ILLUMINATING ENGINEERING ABROAD

(Specially Contributed—H. L. J.)

Sweden.



This illustration, which appeared in "Ljuskultur," shows a meeting hall of the "Vi kan" Exhibition. Lighting equipment is installed in troughs on each side of the hall. General indirect lighting is afforded by 130 300-watt lamps in silver glass reflectors. An illumination of approximately 11 ft.c. on a plane three feet above the floor is available. The bright lines on the ceiling are produced by 120 low voltage 12 volts./100-watt lamps, emitting their light from the same troughs through spotlight lenses. Additional downward direct light is furnished by 200-watt lamps in silver glass reflectors, the illumination being thus increased to about 20 ft.c.

United States of America.

The April issue of the I.E.S. (U.S.A.) "Transactions" published a code on "Recommended Practice of Industrial Lighting" which is the result of very detailed investigations into the relation between lighting conditions and production. It contains recommended illumination values for approximately fifty different industries. In many cases where particular items of production need exceptional treatment specific recommendations are made; for instance, in the case of local lights reference is made not only to the level of illumination but also to the type of fitting, the method of construction, and its position in relation to the task. There are also certain forms of work to which values of illumination are not assigned and which are dealt with in appendices in which other important considerations such as contrast and reflected images are discussed.

The introductory statement emphasises the results of better light in factories, such as the economic advantages of improved output, fewer faults, and better utilisation of floor space. In general an increase of illumination values to approximately 20 ft.c. is recommended. An increase to this value from 1 ft.c. (which is the average value in the factories surveyed) would result in the speed of seeing being multiplied approximately three times. It is strongly recommended that one member of the engineering staff in every factory should be appointed to deal with lighting provision and maintenance of lighting equipment. It is also suggested that the Luckiesh-Moss Visibility Meter should be utilised in cases where specific lighting problems have to be investigated and the level of illumination has to be defined for a particular task.

The value of good maintenance is demonstrated by the case of a factory where the illumination was found to be 49 per cent. of what could have been achieved if maintenance had been properly undertaken, i.e., the repainting of walls and ceilings, regularly cleaning lamps and reflectors, and replacing lamps by new ones of the correct type. Automatic control of lighting by photo-electric equipment, in order to ensure maintenance of proper lighting conditions and particularly the maintenance of sufficient illumination when it is not possible to make use of natural daylight, is advised.

Equipment for general lighting is usually of the direct type. Fittings designed for such purposes should provide for a cut-off of at least five degrees below the horizontal. Fittings providing specially for light emission above the horizontal tend more and more to be used exclusively in offices.

A strong demand is made for adequate wiring and the extensive use of the handbook, "Indoor Wiring Design." The use of copper wire of ample gauge is advocated and, with a view to avoiding a large voltage drop, a certain flexibility of the wiring installation should be allowed, so that the conditions provided for the first installation do not completely load the available circuits.

Germany.

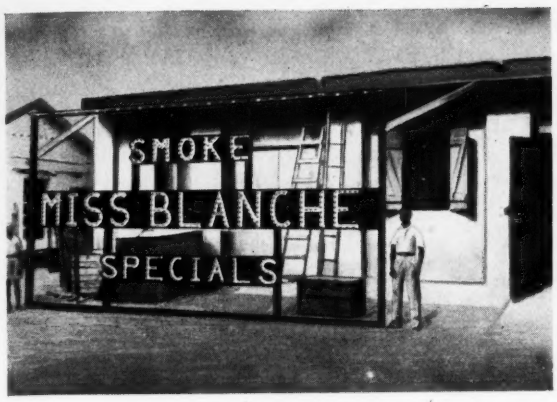
The Chancellory recently built in the Wilhelmstrasse (the "Whitehall" of Berlin) contains many unusually elaborate lighting installations for the different rooms, which are described in a recent contribution to "Das Licht." Among these is the so-called "Mosaic" room, which is equipped with a particularly wide lay-light. This allows the unhindered transmission of natural light during the day and is furnished with artificial light sources, behind the lay-light, which afford a completely even light-distribution in the room after dark. In addition, the lay-light is framed by three cornices one above the other and each illuminated with a different intensity, thus achieving some sort of gradual step up in brightness. The general illumination of the floor is about 23 ft.c.

Another item of interest is the provision of artificially lighted windows in the Marble Gallery. This gallery has only a relatively low illumination by wall brackets, but after dark the windows receive light from floodlighting units, mounted in suitable positions outside the windows, thus bringing up the interior lighting to a sufficient level.

Yet another feature is the treatment of the courtyard. This is effected by a facade, the recesses of which are illuminated after dark by floodlighting from silver glass reflectors placed in a channel at the base of each recess; the lighting units directing their light partly on the recess and partly on the opposite side of the courtyard. This installation, purely by means of reflection from the facades, illuminates the whole of the courtyard to an average value of 3 ft.c.

In the treatment of the outside of the building an effort has been made to combine street lighting and flood-lighting and to provide for as unrestricted a view as possible of the building facade. The main front of the Chancellory lies in the Vossstrasse which is approximately 435 m. long and comparatively narrow. Experiments were made over a length of 90 m. Floodlighting reflectors, four in each unit, were mounted 22 m. above street level on the roof of the opposite buildings so as to serve for street lighting purposes. To prevent undue glare the reflectors were equipped with specially designed louvres. Four additional reflectors were fixed to flood the upper part of the Chancellory only, giving a perfectly even illumination all over the front of the building. The installation has now been extended to the whole length of the street and comprises twenty-one such units. In all, 178 reflectors with a total load of 173 kW. are now in use. The illumination of the street is round about 2 ft.c.

Illuminated Signs in Nigeria



A store in Lagos with sign illuminated by 436 Osram lamps. It is the first sign of its kind in Nigeria.

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Notes on Transactions (April, 1939)

NEWS: *The Convention of the American Association of School Administrators was held in Cleveland from February 25 to March 2.* On this occasion the I.E.S. stand was visited by approximately 1,000 people. Copies of the "American Recommended Practice of School Lighting" was asked for by 464 members of City and Town School Boards and the U.S. Office of Education, and by eight State Departments of Education.—Philadelphia is on the point of carrying out *a re-lighting programme for* 5,000 *classrooms*, involving the fixing of 32,000 new indirectly working light fittings.—*The U.S. Junior Chamber of Commerce is organising a contest* with the slogan "Live Longer with Light," to investigate street accidents and the influence of street lighting arrangements thereon.—The Travellers' Insurance Company has published *an analysis of street accidents* during the past few years which reveals that from 1930-37 deaths from car accidents after dark increased by 54.5 per cent., that although the heaviest car traffic is in the daytime, the largest number of accidents takes place during the night. Six out of every ten deaths occur while three out of every four cars are safely garaged for the night.

SUBJECTS OF PAPERS: "*Recommended Practice of Industrial Lighting.*" This report deals with the details of light application and lighting equipment for approximately fifty different industries; a table of recommended ft.c. values is presented, and types of local lights for certain seeing tasks within these industries are described.

"*Engineering Aspects of Direct Lighting. Part II. Transmitting Systems.*" By J. M. Ketch and L. G. Gianini. The aim of this paper is to assist the development of design by the tabulation of conclusions in regard to desirable conditions of direct illumination in prescribed situations. Different sized reflectors of the polished metal prismatic type, having varying cavities and of different size, equipped with 100, 200 or 300 watt, either clear or frosted lamps, have been investigated. The reflection factors of the finishes used varied from 0.85 down to 0.54. The transmission factors of the glasses used varied from 0.40 in cased opal to 0.60 for ribbed glass. All photometric measurements were made on a rotating-head mirror photometer, and the brightness measured from a distance of 10 ft., using a light-sensitive disc cell connected to a deflection galvanometer. The effect of different sizes of cavities was shown by the investigation of a recess 2 ft. square and 9 in. deep containing four lamps, as compared with the standard test cavity of 1 ft. square and 9 in. deep. The reflection factor of the interior surface in each case was 0.85. The test showed that the 1 ft. square luminaire had an output of 38 per cent., and the 2 ft. square of 54 per cent. Concentrating lens fittings are most sensitive to the light centre position; spreading lenses are less sensitive. The influence of frosted bulb lamp surfaces on light distribution, in comparison with clear glass, was also shown by a series of examples.

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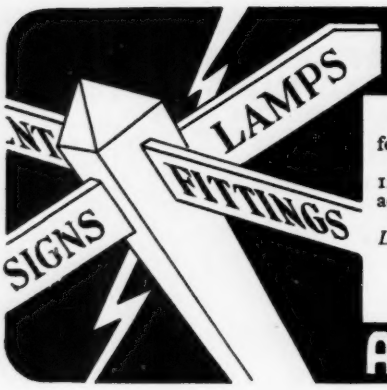

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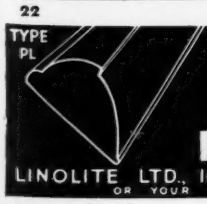
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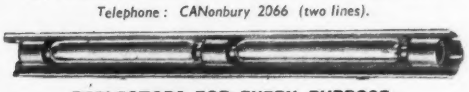
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SPECIALISTS IN COLOUR LIGHTING and STAGE EQUIPMENT
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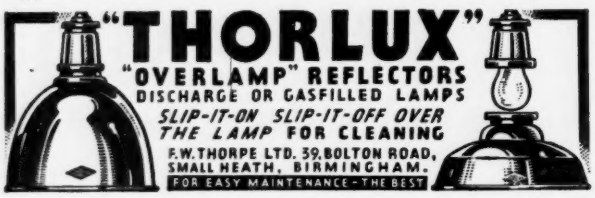
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Engineer, a graduate of the Lichttechnische Institut at Karlsruhe (Germany), with eight years' experience as a manufacturer of lighting fittings, and a special knowledge of enamelling plant, desires post with a firm interested in illuminating engineering.—Write, Box 505, "Light and Lighting," 32, Victoria-street, London, S.W.1.

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N.B.—The numbers are those attached to individual entries in the Directory (See pp. 134—136)

Krypton-filled Miners' Lamp Bulbs

The krypton-filled Osram miners' lamp bulbs recently introduced by the General Electric Co., Ltd., give about 20 per cent. more light than ordinary gas-filled lamps without any increase in current consumption or reduction in life. This rare gas, krypton, found in the atmosphere in the proportion of only one part in a million, reduces the loss of energy from the filament and thus increases the overall efficiency. It is calculated that the increase in light-output of miners' lamps has reached a ratio of 4 to 1 over the period 1932-36. In the same period the cost of compensation paid to sufferers from nystagmus (a disease associated with feeble illumination in mines) has materially diminished. There can be no doubt that any cost involved in improved lighting is well worth while. The new lamps are described in detail in a recently issued G.E.C. leaflet (OS.8377).

New Street Lighting—A Novel Ceremony

A new street lighting installation at Hebburn, Newcastle-on-Tyne, where four miles of main roads are lighted by Osira lamps and twenty miles of secondary roads with tungsten lighting, was recently inaugurated with a novel ceremony, arranged by the North-Eastern Electric Supply Co., Ltd.

The ceremony was held in a darkened room at the Royal Station Hotel, Newcastle. The chairman of the council, Mr. R. Ferguson, operated a switch which lighted up a map of Hebburn, showing the complete new lighting, which he formally declared open. The map had been painted with fluorescent materials, the main roads being shown in light blue to represent Osira, and the secondary roads in light orange colour, denoting tungsten. Osira "black" lamps were focused on to the map.

Gas Lighting in St. Helens

The lamps used in St. Helens for the improvements for which the Ministry of Health Loan has been sanctioned are of the Avil "Arcturus" type, having 4 lt. N. 2-cluster burners and "registered Back" reflectors in "Staybrite" steel. This is a smaller form of the lamp illuminating Clifton-terrace, Folkestone, and is manufactured by Messrs. Foster and Pullen, Ltd. (Avil Works, Bradford).

"This Made a New World"

Under this title the story of town gas is told in a little brochure issued by the British Commercial Gas Association. The history of gas and its manifold applications are touched upon, its value as a heating agent and the utility of its by-products are explained. The booklet is illustrated by effective pictures and diagrams showing, for example, the process of gas manufacture and the variety of everyday things derived from by-products of coal.

Philips New Headquarters

Philips Lamps, Limited, have now vacated their offices in Charing Cross-road and are in occupation of their new eight-storey building at the northern end of Shaftesbury-avenue. Since May 22 their new address has been: Philips Lamps, Limited, Century House, Shaftesbury-avenue, London, W.C.2.

The telephone number (Gerrard 7777) remains unchanged.

Contracts Closed

SIEMENS ELECTRIC LAMPS AND SUPPLIES, LTD.,—*The Air Ministry* and the *Post Office Stores Dept.*: for twelve months' supply of Siemens British-made Electric Lamps of various types.